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RESEARCH ARTICLE

K ANGLE: A NEW INDICATOR OF SAGITTAL JAW RELATIONSHIP

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ABSTRACT

Aims and Objectives: To introduce K angle, a new cephalometric measurement to assess the sagittal jaw relationship. To define the mean value, the standard deviation for Kangle in people with the skeletal class I pattern and to determine whether there is a statistically significant difference between the mean value of Kangle between the skeletal class I, class II and class III groups.
Materials and Methods: Seventy-five pretreatment lateral cephalograms (twenty-five each of Class I, II, and III) of patients between the age of 18 and 30 years were selected. They were again subdivided based on ANB and Wits appraisal into skeletal class I, class II, and class III groups, each group having twenty-five radiographs. The new measurement is based on the landmarks: Point M (midpoint of the anterior maxilla), Point G (center at the bottom of the symphysis) and apparent axis of the condyle (C). The K angle is the inferior angle measured at Point M, between the lines M-G and perpendicular from Point M to line C-G.
Results: Subjects with K angle value between 40° and 46° were found to have a skeletal class I pattern. More acute angles implied skeletal class II pattern and more obtuse angles implied skeletal class III pattern.
Conclusion: The K angle is an accurate, stable, reliable and reproducible parameter for the assessment of sagittal jaw relationship.

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INTRODUCTION

The relative size and antero-posterior (AP) position of the maxilla in relation to the mandible, particularly in the profile view is of utmost importance to an orthodontist. E.H.Angle introduced his classification of malocclusion to the profession in the early 1900's as the antero-posterior (AP) relation of mandible to maxilla was an important diagnostic criterion (Riedel, 1952).

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This relationship can be determined from clinical observation to some degree, but it can be much more accurately evaluated from a lateral cephalogram. Angularand linear measurements have been incorporated into various cephalometric analyses to help the clinician diagnose AP discrepancies. All these measurements have shortcomings, which Moyers et al. (1979) had discussed. Brodie (1941) listed the advantages of using angles. Down's (1948) description of Points A and B in 1948 was one of the earliest in evaluating AP apical base relationships cephalometrically. He measured the angles formed by the A-B and N-P (facial) lines. Riedel, (1948) measured SNA and SNB angles and their difference i.e. angle ANB as an expression of dental apical base relationship.

It has been demonstrated in literature (Freeman, 1981; Jacobson, 1975; Hussels, 1984; Holdaway, 1956; Taylor, 1969; Jarvinen, 1985; Beatty, 1975) that there is often a difference between the interpretation of the ANB angle and the actual discrepancy. Several authors (Freeman, 1981; Moore, 1959; Enlow, 1966; Nanda, 1955) have shown, that the position of nasion is not fixed during growth and any displacement of nasion will directly affect the ANB angle (Binder, 1979). As an alternative to ANB, Jacobson introduced Wits appraisal (Jacobson, 1975; Jacobson, 1976) which relates Points A and B to the functional occlusal plane. However accurate identification of the occlusal plane is not easy (Haynes, 1995; Demisch et al., 1977) and any change in the angulation of the functional occlusal plane, caused by either normal development of the dentition or orthodontic intervention, can influence the Wits appraisal (Rushton et al., 1991; Frank, 1983; Richardson, 1982).

Some authors suggested angles or linear measurements based on the palatal plane, but its inclination is highly variable, making it difficult to establish mean values (Sherman, 1988). Baik and Ververidou, 2004 introduced the Beta angle which uses three skeletal landmarks – Point A, Point B and the apparent axis of the condyle. The disadvantage is that it uses Point A which is not stable and is affected by alveolar bone remodelling associated with orthodontic tooth movement of upper incisors (Arvystas, 1990; Erverdi, 1991; Nanda, 2009). Neela et al. (Neela et al., 2009) have introduced YEN angle which uses the landmarks: (i) Point S: midpoint of the sellaturcica; (ii) Point M: midpoint of the premaxilla and (iii) Point G: the center of the largest circle that is tangent to the internal inferior, anterior and posterior surfaces of the mandibular symphysis. Since it measures the angle formed by the lines SM and SG, rotation of jaw due to growth or orthodontic treatment can mask true basal dysplasia. Using the same landmarks as of YEN angle, Bhad et al. (2011) introduced the W angle which is measured between the perpendicular from Point M on S-G line and the M-G line. This study introduces K angle, a new angle developed for the purpose of determining the antero-posterior changes and to define the mean value and the standard deviation for this angle in people with the Class I skeletal pattern, to determine whether there is a statistically significant difference between the mean value of K angle between the Class I, Class II and Class III skeletal pattern population groups, and how that angle changes in those three groups.

MATERIALS AND METHODS

This is a retrospective comparative study. Seventy five cephalometric radiographs (Twenty five each of class I, class II and class III patients) were selected for this study. The radiographs were selected randomly from the record archives of department. Cephalometric measurements are carried out manually.The patients' age ranged from18 to 30 years.

Class I group contained patients with skeletal class I relationship corroborated by ANB values of 2º ± 2º (i.e. 0º to 4º) and Wits appraisal of AO coinciding with BO in females or BO ahead of AO by 1mm in males.

Class II group containedpatients with skeletal class II relationship corroborated by ANB values of greater than 4º and Wits appraisal of AO ahead of BO in females or AO coinciding with or ahead of BO in males.

Class III group containedpatients with skeletal class III relationship corroborated by ANB values of less than 0º and Wits appraisal of BO ahead of AO in females or BO ahead of AO by more than 1mm in males. Patients with less than 24 permanent teeth or suffering from craniofacial anomalies or systemic muscle or joint disorders were excluded. Only good quality radiographs were included.

Following skeletal landmarks are identified: (Figure 1)

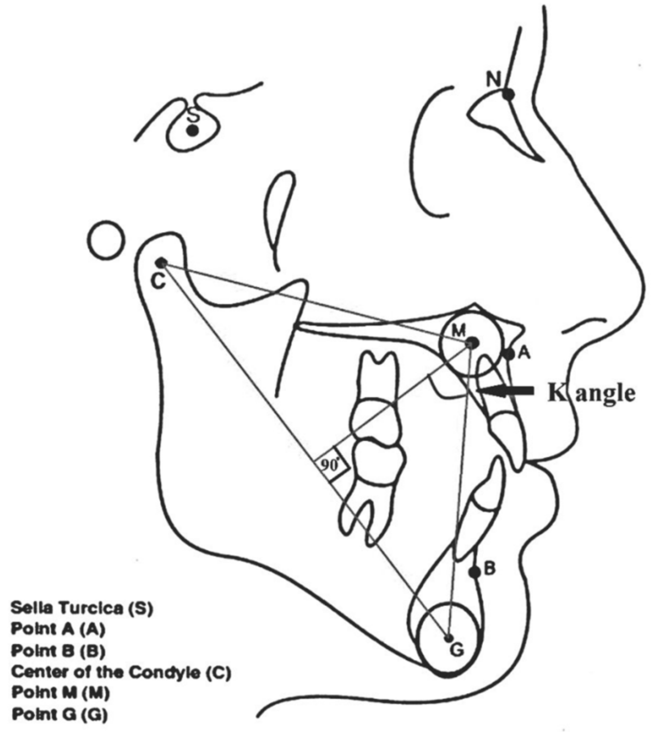

Figure 1 Construction of K angle: It is measured as the inferior angle between the lines M-G and the perpendicular from point M projected on the line joining apparent axis of condyle (C) and point G

Center of the condyle (C): Found by tracing the head of the condyle and approximating its center

Point M: Midpoint of premaxilla. The best fit circle which is tangent to the superior, anterior and the palatal surfaces of maxilla, center of it represents Point M (Baik, 2004).

Point G: Center of the largest circle that is tangent to the internal inferior, anterior, and posterior surfaces of the mandibular symphysis (Williams et al., 1985).
To locate Points M and G, a template with concentric circles whose diameters increased in 1 mm increments was used (Baik, 2004; Williams et al., 1985).

The following lines are drawn:

- Lines connecting the center of the condyle C with M Point (C-M line).
- Lines connecting the center of the condyle C with G Point (C-G line).
- Lines connecting M and G Points.
- Line from Point M perpendicular to the C-G

K angle (Mitra, 2013)– Inferior angle between M-G line and perpendicular from Point M to C-G line

Statistical analysis used: Data was summarized by finding means and standard deviations. The 1-way analysis of variance (ANOVA) was used to determine whether there was a statistically significant difference between the mean values of the 3 groups. A p value ≤ 0.05 was considered to be statistically significant. The correlations in the results of the measurements wereanalyzed using intra-class correlation coefficient. Correlation of ANB and Wits with K- angle was done using Karl Pearson correlation coefficient (r).

RESULTS

The present study comprised of seventy-five subjects divided into three groups of twenty-five each. The measurements were done individually by all investigators and their mean was taken. The mean age and standard deviation for the classes I, II and III were 20.36 ± 1.98, 19.8 ± 1.71 and 20.76 ± 2.17 respectively. One - way ANOVA revealed that the difference in the mean age in the three groups was not statistically significant (Table 1). The mean and standard deviation of K angle was found to be 43.18 ± 3.04; 36.36 ± 3.12; 52.7 ± 4.13 in skeletal class I, class II and class III groups respectively (Table 2). The age of the subjects also did not affect the value of the K angle within the groups. (Table 3). The gender wise distribution is not statistically significant. (Table 4)

DISCUSSION

In orthodontic diagnosis and treatment planning, the evaluation of the AP jaw relationship is an indispensable step and this relationship is generally determined by cephalometric analysis.

Table 1. Age distribution of subjects studied

	N	Mean Age	Std. deviation	95% Confidence Interval for Mean		ANOVA F	P
				Lower bound	Upper bound		
Class I	25	20.36	1.98	19.54	21.18	1.515	0.227 NS*
Class II	25	19.80	1.71	19.10	20.50		
Class III	25	20.76	2.71	19.87	21.65		
Total	75	20.31	1.97	19.85	20.76		

*Non-significant

Table 2. Mean Value of K Angle In The Three Different Skeletal Classes

	N	Mean Age	Std. deviation	95% Confidence Interval for Mean		ANOVA F	P
				Lower bound	Upper bound		
Class 1	25	43.18	3.04	42.38	44.98	73.951	0.000
Class 2	25	36.36	3.12	35.25	37.97		HS
Class 3	25	52.70	4.73	50.25	55.15		
Total	75	44.58	5.83	42.80	46.36		

Table 3. Effect of Age On K Angle Value

AGE	K ANGLE	CLASS	N	Mean Age	Std. deviation	95% Confidence Interval for Mean		ANOVA F	P
						Lower bound	Upper bound		
		Class I	25	20.36	1.98	19.54	21.18	1.515	0.227 NS*
		Class II	25	19.80	1.71	19.10	20.50		
		Class III	25	20.76	2.71	19.87	21.65		
		Total	75	20.31	1.97	19.85	20.76		

*NS: Non significant

Table 4.Genderwise Distribution of K Angle

CLASS	SEX	MEAN	SD	P VALUE
CLASS 1	M	43.1250	3.38533	.408 NS*
	F	44.1923	2.96886	
CLASS 2	M	37.6667	4.45856	.714 NS*
	F	37.0769	3.47519	
CLASS 3	M	50.5000	4.14327	.051 NS*
	F	55.0833	6.78847	

*NS Non Significant

Table 5. Table of earlier indicators and their shortcomings

INDICATOR	AUTHOR	SHORTCOMINGS
Angle between A-B & N-P lines	Down	The position of point A is not fixed during growth
ANB	Riedel	The position of point A is not fixed during growth and any displacement of nasion will directly affect the ANB angle
WITT’s Appraisal	Jacobson	Accurate identification of the occlusal plane is not always easy or accurately reproducible and any change in the angulation of the functional occlusal plane, caused by either normal development of the dentition or orthodontic intervention, can profoundly influence the Wits appraisal.
Angles based on the palatal plane	Several authors	Inclination of palatal plane is highly variable, making it difficult to establish mean values for the norm.
The Beta angle	Baik and Ververidou	It uses Point A which is not stable as it is believed to be and is affected by alveolar bone remodelling associated with orthodontic tooth movement of upper incisors.
YEN angle	Neela et al.	Rotation of jaw due to growth or orthodontic treatment can mask true basal dysplasia.
W angle	Bhad et al.	Uses Sella (S) which is unrelated to the face or jaws

To evaluate this relationship, various angular and linear measurements have been suggested. But these can be erroneous as angular measurements are affected by changes in face height, jaw inclination and total jaw prognathism. Linear variables can be affected by the inclination of the reference line (Hall-Scott, 1994). A very popular parameter for assessing the sagittal jaw relationship remains the ANB angle, but it is affected by various factors and can often be misleading. As Jacobson[7] noted, it is affected by the patient's age, growth rotation of the jaws, vertical growth, and the length of the anterior cranial base. Moreover, to identify point A precisely, good quality radiographs are a prerequisite, which then becomes a drawback of this parameter.

Wits appraisal was suggested to overcome the existing fallacies of ANB. Though it avoids the use of nasion and reduces the rotational effects of jaw growth, it uses the occlusal plane, which is a dental and not a skeletal parameter. A change of the cant of the occlusal plane, for instance, with growth (Frank, 1983; Sherman, 1988; Harvold, 1963) will lead to a different Wits value. The points used to define the functional occlusal plane are close together, making plane identification difficult even under perfect conditions (Ishikawa, 2000), especially in the mixed dentition after shedding of the deciduous molars but before the eruption of the premolars. Furthermore, changes of the Wits measurement throughout orthodontic treatment might also reflect changes in the functional occlusal plane rather than pure sagittal changes of the jaws (Palleck et al., 2001). To overcome these problems, the Beta angle was developed. This measurement does not depend on cranial landmarks or the functional occlusal plane. The configuration of the Beta angle gives it the advantage to remain relatively stable even when the jaws are rotated. Therefore, the Beta angle can assess the sagittal jaw relationship in skeletal patterns, when clockwise or counter-clockwise rotation of the jaws would tend to camouflage it. Precisely tracing the condyle and locating its center is not always easy. For that reason, some clinicians might hesitate to use the Beta angle. It still depends on points A and B, which according to Holdaway (1956) change their site substantially due to both treatment and growth.

YEN angle was developed to overcome some of the deficits of the previously discussed parameter. The authors claim that it is not influenced by growth changes and can easily be used in the mixed dentition. In comparison to Beta angle this angle uses points M and G which are more stable than points A and B. The disadvantage with this angle is that since it measures an angle between line SM and MG, rotation of jaw because of growth or orthodontic treatment can mask true basal dysplasia, similar to ANB angle. Recently, W angle has been introduced as an indicator of the sagittal jaw base relation. The geometry of the W angle gives it the advantage to remain relatively stable even when the jaws are rotated or growing vertically. This is a result of rotation of the S–G line along with jaw rotation, which carries the perpendicular from point M with it. Because the M–G line is also rotating in the same direction, the W angle remains relatively stable. Therefore, measurement of W angle is a useful sagittal parameter in skeletal patterns with clockwise or counter-clockwise rotation of the jaws as well as during transitional period when vertical facial growth is taking place. However, this angle uses Sella (S) which is unrelated to the face or jaws in particular. Furthermore, this point is marked in space; hence Hunter calls it a "space mark" rather than a landmark as it lacks craniometric definition (Naragond et al., 2012). Table 5 summarizes all the above indicators and their shortcomings. An accurate indicator of the sagittal relationship which does not suffer from the demerits of the previously mentioned parameters is therefore very necessary to the orthodontic practice. Hence a new indicator, the K angle has been introduced through this study. K angle uses three points located on the jaws— point M, point G, and the apparent axis of the condyle (point C)—so changes in this angle reflect only changes within the jaws unlike Yen and W angle which uses point S, which is a part of the cranium. Moreover since it uses the points M and G which are more stable than points A and B, it makes it more reliable than the Beta angle. The angle is measured at M and is formed inferiorly between the lines M-G and the perpendicular from M to line C-G.

In the class I subject the mean and standard deviation of K angle was found to be 43.18 ° ± 3.04. The mean age of the group was 20.36 years ± 1.98 SD.In the class II subjects the mean and standard deviation of K angle was found to be 36.36 ° ± 3.12. In the class III subjects the mean and standard deviation of K angle was found to be 52.7 ° ± 4.13. Unlike the ANB angle, the configuration of K angle renders it an inherent advantage in remaining stable even when the jaws are rotated or growing vertically. For example when G point is rotated backward and downward, then the C-G line is also rotating in the same direction, carrying the perpendicular from point M with it. Since the M-G line is also rotating in the same direction, the K angle remains relatively stable. Therefore, the K angle can assess the sagittal jaw relationship in skeletal patterns, when clockwise or counter-clockwise rotation of the jaws would tend to camouflage it. Another advantage of the K angle is that it can be used in assessment of treatment progress because it reflects true changes of the sagittal relationship of the jaws, which might be due to growth or orthodontic or orthognathic intervention.

However, precisely tracing the premaxilla and locating its center is not always easy. Also the condyle might not be clearly seen. To accurately use this angle, the cephalograms must be of good quality. The advantage of locating the center of the head of the condyle is that very precise tracing of the contour of the condyle is not really necessary and if approximated the center within 2 mm of its actual location, it will lead to a minimum error in the K angle value which would be approximately 1° and not significant (Arvystas, 1990). The K angle can be a valuable tool when planning orthognathic surgery for patients with sagittal and vertical skeletal deformities, because it can help to distinguish between true skeletal Class I, Class II, and Class III patterns. Cephalometric analyses based on angular and linear measurements have obvious limitations and hence dependency on any one parameter for skeletal assessment is discouraged. K angle enriches the present cephalometric tools for assessment of AP jaw relationship and with other parameters; it should enable better diagnosis and treatment planning for the patients.
On serial re-tracing of the cephalograms by the authors, similar results of K angle were obtained.

Conclusion

- A new cephalometric parameter named K angle, was developed as a diagnostic tool to evaluate the AP jaw relationship more consistently.

- Subjects with a K angle between 40 and 46 degrees have a skeletal Class I pattern; a K angle less than 40 degrees indicates a skeletal Class II pattern and a K angle greater than 46 degrees indicates a skeletal Class III pattern.
- Age of the patient or the gender did not seem to affect the value of K angle within each class.

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